

Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11) EP 0 942 407 A1

(12) **EUROPEAN PATENT APPLICATION**  
published in accordance with Art. 158(3) EPC

(43) Date of publication:  
15.09.1999 Bulletin 1999/37

(21) Application number: 98902258.7

(22) Date of filing: 16.02.1998

(51) Int. Cl.<sup>6</sup>: G09G 3/30, H05B 33/08,  
H01L 33/00

(86) International application number:  
PCT/JP98/00646

(87) International publication number:  
WO 98/36405 (20.08.1998 Gazette 1998/33)

(84) Designated Contracting States:  
DE FR GB NL

(30) Priority: 17.02.1997 JP 3248097

(71) Applicant:  
SEIKO EPSON CORPORATION  
Tokyo 163 (JP)

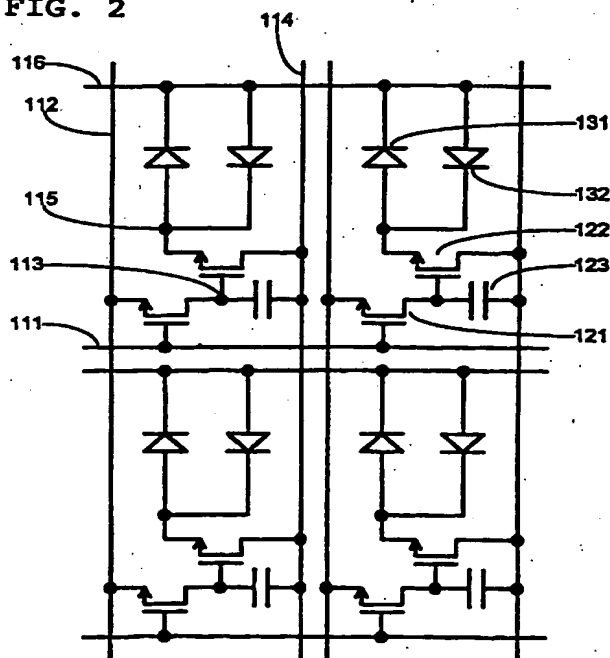
(72) Inventor:  
KIMURA, Mutsumi,  
Seiko Epson Corporation  
Nagano-ken 392-8502 (JP)

(74) Representative:  
Sturt, Clifford Mark et al  
Miller Sturt Kenyon  
9 John Street  
London WC1N 2ES (GB)

(54) **CURRENT-DRIVEN EMISSIVE DISPLAY DEVICE, METHOD FOR DRIVING THE SAME, AND METHOD FOR MANUFACTURING THE SAME**

(57) A reduction in deterioration of a switching element over time in a current driving type emissive apparatus is realized. At the same time, a reduction in power consumption is realized. To this end, an AC voltage or an alternating current is applied between a source and a drain terminal of a switching element, and a DC voltage or a direct current is applied between a first and a second terminal of a luminescent element. This is realized by application of a voltage, which is inverted at predetermined intervals, to two luminescent elements heterogeneously arranged, to a luminescent element and a rectifier arranged in reverse orientation and in parallel, or to a full-wave rectification circuit. At this time, the rectifier is formed by a thin-film transistor, a PN junction, or a PIN junction, and is formed simultaneously with an existing switching element.

FIG. 2



## Description

### Technical Field

[0001] The present invention relates to a current driving type emissive display apparatus such as an organic electro luminescence (hereinafter referred to as an "organic EL") device having a thin-film transistor and a method for driving the apparatus, and more particularly, to a technique for realizing a reduction in deterioration over time or a reduction in both deterioration over time and electric power consumption simultaneously.

### Background Art

[0002] An operation of a conventional current driving type emissive apparatus such as an organic EL having thin-film transistors will be described with reference to Figs. 16, 17, and 18.

[0003] Fig. 16 is an equivalent circuit diagram of one pixel of the conventional organic EL display device having thin-film transistors, Fig. 17 is an equivalent circuit diagram showing a matrix construction of the conventional organic EL display device having thin-film transistors, and Fig. 18 is a driving voltage diagram of the conventional organic EL display device having thin-film transistors.

[0004] Provided are: a data line 112; a first switching element 121 (hereinafter referred to as a "switching thin-film transistor") in which the source terminal side is connected to the data line 112 and a gate electrode is connected to a scanning line 111; a holding electrode 113 for storage capacity, in which one terminal is connected to the drain terminal side of the switching thin-film transistor 121; a second switching element 122 (hereinafter referred to as a "current thin-film transistor"), in which a gate terminal is connected to the drain terminal of the switching thin-film transistor and the source terminal is connected to a first feeder 114; and an organic EL device 135, one terminal of which is connected to the drain terminal of the current thin-film transistor and the other terminal of which is connected to a second feeder.

[0005] The switching thin-film transistor 121 controls the conduction between the data line 112 and the holding electrode 113 by the potential of the scanning line 111. That is, a scanning potential 211 controls the conduction between a signal potential 212 and a holding potential 213. Although an n-channel type thin-film transistor is employed as the switching thin-film transistor 121 in this example, a p-channel type thin-film transistor may also be employed. In such an example the high-potential-side of the scanning potential 211 and the low-potential-side thereof are reverse to those of this embodiment.

[0006] In a pixel in a displaying condition, the signal potential 212 is high and the high potential is held at the holding potential 213. In a pixel in a non-displaying con-

dition, the signal potential 212 is low and the low potential is held at the holding potential 213.

[0007] The current thin-film transistor 122 controls the conduction between the first feeder 114 and a pixel electrode 115 by the potential of the holding electrode 113. That is, the holding potential 213 controls the conduction between a first feed potential 214 and a pixel potential 215. Although an n-channel type thin-film transistor is employed as the current thin-film transistor 122 in this example, a p-channel type thin-film transistor may also be employed. In such an example the high-potential-side of the signal potential 212 and the low potential thereof are reverse to those of this embodiment.

[0008] In a pixel in a displaying condition, the holding potential 213 is high, so the first feeder 114 and the pixel electrode 115 are electrically connected. In a pixel in a non-displaying condition, the holding potential 213 is low, so the conduction between the first feeder 114 and the pixel electrode 115 is interrupted.

[0009] In a pixel in a displaying condition, the current flows from the first feeder 114 through the current thin-film transistor 122 and the pixel electrode 115 to a second feeder 116, and the organic EL device 135 emits light. In a pixel in a non-displaying condition, no current flows, and the organic EL device will not emit light.

[0010] Since the first feed potential 214 is higher than a second feed potential 216, the current flows from the first feeder 114, through the current thin-film transistor 122, the pixel electrode 115, and the organic EL device 135 to the second feeder 116.

[0011] The actual operation of organic EL display apparatuses with thin-film transistors is not as simple as that described above and the devices operate under more complex relationships of voltages and currents. Similarly and qualitatively, however, the above description holds true.

[0012] Fig. 19 is a sectional view of the organic EL display apparatus having a conventional thin-film transistor. Fig. 20 is a plan view of the organic EL display apparatus having the conventional thin-film transistor. A section taken along the line A-A of Fig. 19 corresponds to a section taken along the line A-A' of Fig. 20.

[0013] In the organic EL device 135, a current flows from a high-electric-potential-side electrode 165 of the organic EL device through a luminescent material 155 for the organic EL device to a low-electric-potential electrode 175 of the organic EL device. Although PPV, ITO, and Al are respectively employed as the luminescent material for the organic EL device 155, the material for the high electric potential side electrode 165 of the organic EL device, and the material for the low-electric-potential electrode 175 of the organic EL device in this example, other materials may also be used.

[0014] In the conventional example, in which an AC voltage is applied between the source terminal and the drain terminal of the switching thin-film transistor 121, to cause an alternating current to flow, a DC voltage is

applied between the source terminal and the drain terminal of the current thin-film transistor 122 to disadvantageously cause a direct current to flow. This is due to an asymmetric configuration optimizing the materials of the high and low-potential-side in order to improve the luminous efficiency of the organic EL device 135; the organic EL device emits light because of the DC voltage being applied causing the direct current to flow. However, when a DC voltage is applied not only to the organic EL device but also to the thin-film transistor or a direct current flows, a rapid deterioration of the thin-film transistor over time will be caused.

[0015] On the other hand, an AC voltage may also be applied between the source terminal and the drain terminal of the current thin-film transistor 122. In this case, an alternating current will not flow through the organic EL device 135, but only a one-way current flow, because of the rectification of the organic EL device 135. In other words, the organic EL device 135 emits light in one direction, while it does not emit light in the other direction, so that the luminous efficiency deteriorates. Thus it requires an increase in power consumption to obtain the same amount of light emission as in the case in which a DC voltage is applied to cause a direct current to flow.

#### Disclosure of Invention

[0016] Thus, an object of this invention is to reduce deterioration over time of a switching element such as a thin-film transistor in a current driving type emissive apparatus such as an organic EL display device having a thin-film transistor. Another object of this invention is to reduce in deterioration over time of a switching element such as a thin-film transistor, and to simultaneously achieve both improvement in luminous efficiency and reduction in power consumption.

[0017] To solve the above problems, this invention, as claimed in claim 1, comprises a plurality of scanning lines, a plurality of data lines, and thin-film transistors and a luminescent element formed in a manner such that they correspond to each intersection of the scanning lines and the data lines, wherein an AC voltage is applied between source and drain terminals of the thin-film transistors and wherein a DC voltage is applied between first and second terminals of the luminescent element.

[0018] In accordance with this invention, as claimed in claim 1, not only reduction in the deterioration of thin-film transistors over time due to a direct current, but also improvement of the luminous efficiency of the luminescent elements can be realized.

[0019] This invention, as claimed in claim 2, comprises a plurality of scanning lines, a plurality of data lines, and thin-film transistors and a luminescent element formed in a manner such that they correspond to each intersection of the scanning lines and the data lines, wherein an alternating current flows between source and drain terminals of the thin-film transistors

and wherein a direct current flows between first and second terminals of the luminescent element.

[0020] In accordance with this invention, as claimed in claim 2, not only reduction in deterioration of thin-film transistors over time due to a direct current, but also improvement of the luminous efficiency of the luminescent element can be realized.

[0021] This invention, as claimed in claim 3, is a current driving type emissive apparatus which comprises a plurality of scanning lines, a plurality of data lines, a first feeder, and a second feeder, the current driving type emissive apparatus having in correspondence with each intersection of the scanning lines and the data lines, a first switching element, a second switching element, a storage capacitor, a pixel electrode and a luminescent element, the first switching element controlling conduction between the data lines and the storage capacitor by means of a potential of the scanning lines, the second switching element controlling conduction between the first feeder and the pixel electrode by means of a potential of the storage capacitor, to thereby control a current flowing through the luminescent element arranged between the pixel electrode and the second feeder, wherein the luminescent element comprises a first luminescent element that emits light by a current flowing from the pixel electrode to the second feeder and a second luminescent element that emits light by a current flowing from the second feeder to the pixel electrode, and wherein the first and the second luminescent elements are arranged in parallel.

[0022] In accordance with the invention, as claimed in claim 3, when the potential for the first feeder across the second feeder is inverted at predetermined intervals, an AC voltage is applied between the source and the drain terminals of the second switching element, causing an alternating current to flow. Then since a deterioration of the second switching element over time due to a DC voltage or a direct current can be reduced, and either of the first luminescent element or the second luminescent element can emit light, the power consumption can decrease without deterioration of the luminous efficiency.

[0023] This invention claimed, as in claim 4, is a current driving type emissive display apparatus which comprises a plurality of scanning lines, a plurality of data lines, a first feeder, and a second feeder, the current driving type emissive display apparatus further having, in correspondence with each intersection of the scanning lines and the data lines, a first switching element, a second switching element, a storage capacitor, a pixel electrode and a luminescent element, wherein the first switching element controls conduction between the data lines and the storage capacitor by means of a potential of the scanning lines, the second switching element controls conduction between the first feeder and the pixel electrode by means of a potential of the storage capacitor, to thereby control a current flowing through the luminescent element arranged between the

pixel electrode and the second feeder, wherein the luminescent element and a rectifier are arranged in parallel between the pixel electrode and the second feeder, wherein the luminescent element emits light by a current flowing from the pixel electrode to the second feeder, and wherein the rectifier is formed in a manner such that a current flows from the second feeder to the pixel electrode.

[0024] In accordance with the invention, as claimed in claim 4, an AC voltage is applied between the source and the drain terminals of the first switching element and the second switching element causing an alternating current to flow, and a direct current flows between the first and the second terminals of the luminescent element. Since a luminescent element emits light by a current flowing from the pixel electrode to the second feeder, and the rectifier is constructed in a manner such that a current flows from the second feeder to the pixel electrode, deterioration of the second switching element over time due to a direct current or a DC voltage can be prevented.

[0025] This invention, as claimed in claim 5, is a current driving type emissive display apparatus which comprises a plurality of scanning lines, a plurality of data lines, a first feeder, and a second feeder, the current driving type emissive display apparatus further having, in correspondence with each intersection of the scanning lines and the data lines, a first switching element, a second switching element, a storage capacitor, a pixel electrode and a luminescent element, wherein the first switching element controls the conduction between the data lines and the storage capacitor by means of a potential of the scanning lines, and the second switching element controls the conduction between the first feeder and the pixel electrode by means of a potential of the storage capacitor, to thereby control a current flowing through the luminescent element arranged between the pixel electrode and the second feeder, wherein the luminescent element and a rectifier are arranged in parallel between the pixel electrode and the second feeder, wherein the luminescent element emits light by a current flowing from the second feeder to the pixel electrode, and wherein the rectifier is formed in a manner such that a current flows from the pixel electrode to the second feeder.

[0026] In accordance with the invention, as claimed in claim 5, when a luminescent element emits light by a current flowing from the second feeder to the pixel electrode, and the rectifier is constructed in a manner such that a current flows from the pixel electrode to the second feeder, deterioration over time due to a DC voltage or a direct current can be reduced.

[0027] This invention, as claimed in claim 6, is a current driving type emissive display apparatus which comprises a plurality of scanning lines, a plurality of data lines, a first feeder, and a second feeder, the current driving type emissive display apparatus further having, in correspondence with each intersection of the scan-

ning lines and the data lines, a first switching element, a second switching element, a storage capacitor, a pixel electrode and a luminescent element, wherein the first switching element controls conduction between the data lines and the storage capacitor by means of a potential of the scanning lines, wherein the second switching element controls conduction between the first feeder and the pixel electrode by means of a potential of the storage capacitor, to thereby emit light by a current following through the luminescent element, which is arranged between the first electrode connected to the pixel electrode and the second electrode connected to the second feeder, the current driving type emissive display apparatus further comprising a first rectifier constructed so as to cause a current to flow from the pixel electrode to the first electrode, a second rectifier constructed so as to cause a current to flow from the second electrode to the pixel electrode, a third rectifier constructed so as to cause a current to flow from the second feeder to the first electrode, and a fourth rectifier constructed so as to cause a current to flow from the second electrode to the second feeder, and wherein the luminescent element emits light by a current flowing from the first electrode to the second electrode.

[0028] This invention enables reduction in deterioration of the second switching element over time due to a DC voltage and a direct current.

[0029] This invention, as claimed in claim 7, relates to a method for driving a current driving type emissive display apparatus as claimed in any one of claims 3, 4, and 5, wherein a voltage between the first feeder and the second feeder is inverted at predetermined intervals.

[0030] This invention can realize a direct current caused to flow through a luminescent element, and simultaneously an AC voltage applied between the source and drain terminals of the second switching element causing an alternating current to flow. Additionally, there can be realized a decrease in the deterioration of the second switching element over time due to a DC voltage or a direct current, and simultaneously, the luminous efficiency can be improved and by emission from a luminescent element during both inverting periods of the potential between the first feeder and the second feeder, the power consumption can be reduced.

[0031] This invention claimed, as in claim 8, relates to a method for producing a current driving type emissive display apparatus according to claim 4 or 5, wherein at least one of the rectifiers, the first rectifier, the second rectifier, the third rectifier, and the fourth rectifier comprises a switching element for rectification connected to a gate, a source, or a drain terminal, and wherein the switching element for rectification is formed simultaneously with at least one of the first and the second switching elements.

[0032] The invention, as claimed in claim 9, is a current driving type emissive display apparatus according to claim 4 or 5, wherein at least one of the rectifiers, the first rectifier, the second rectifier, the third rectifier, and

the fourth rectifier is formed by a PN junction or a PIN junction, and formed simultaneously with at least one of the first and the second switching elements.

[0033] This configuration can realize a reduction in the deterioration of the second switching element over time due to a DC voltage or a direct current, and also improvement of the luminous efficiency and reduction in the power consumption by permitting a luminescent element to emit light during both periods of inversion of the potential between the first feeder and the second feeder, without an additional production process.

#### Brief Description of the Drawings

[0034]

Figure 1 is an equivalent circuit diagram of one pixel of an organic EL display device as one example of a current driving type emissive display apparatus having a switching element such as a thin-film transistor of a first embodiment of this invention.

Figure 2 is an equivalent circuit diagram showing a matrix construction of the organic EL display device having the thin-film transistor of the first embodiment of this invention.

Figure 3 is a driving voltage diagram of the organic EL display device having the thin-film transistor of the first embodiment of this invention.

Figure 4 is a sectional view of the organic EL display device having the thin-film transistor of the first embodiment of this invention.

Figure 5 is a plan view of the organic EL display device having the thin-film transistor of the first embodiment of this invention.

Figure 6 is an equivalent circuit diagram of one pixel of an organic EL display device having a thin-film transistor of a second embodiment of this invention.

Figure 7 is an equivalent circuit diagram showing a matrix construction of the organic EL display device comprising the thin-film transistor relating to the second embodiment of the invention.

Figure 8 is a driving voltage diagram of the organic EL display device having the thin-film transistor of the second embodiment of this invention.

Figure 9 is a sectional view of the organic EL display device having the thin-film transistor of the second embodiment of this invention.

Figure 10 is a plan view of the organic EL display device having the thin-film transistor of the second embodiment of this invention.

Figure 11 is an equivalent circuit diagram of one pixel of an organic EL display device having a thin-film transistor of a third embodiment of this invention.

Figure 12 is an equivalent circuit diagram showing a matrix construction of the organic EL display device having the thin-film transistor of the third embodiment of this invention.

Figure 13 is a driving voltage diagram of the organic EL display device having the thin-film transistor of the third embodiment of this invention.

Figure 14 is a sectional view of the organic EL display device having the thin-film transistor of the third embodiment of this invention.

Figure 15 is a plan view of the organic EL display device having the thin-film transistor of the third embodiment of this invention.

Figure 16 is an equivalent circuit diagram of one pixel of an organic EL display device having a thin-film transistor of a conventional form.

Figure 17 is an equivalent circuit diagram showing a matrix construction of the organic EL display device having the thin-film transistor of the conventional form.

Figure 18 is a driving voltage diagram of the organic EL display device having the thin-film transistor of the conventional form.

Figure 19 is a sectional view of the organic EL display device having the thin-film transistor of the conventional form.

Figure 20 is a plan view of the organic EL display device having the thin-film transistor of the conventional form.

#### Reference Numerals

[0035]

111	scanning line
112	data line
113	holding electrode
114	first feeder
115	pixel electrode
116	second feeder
117	first electrode
118	second electrode
121	switching thin-film transistor
122	current thin-film transistor
123	storage capacitor
131	forward oriented organic EL device
132	reverse oriented organic EL device
133	organic EL device
134	organic EL device
135	organic EL device
141	rectifier
142	first rectifier
143	second rectifier
144	third rectifier
145	fourth rectifier
151	luminescent layer of forward oriented organic EL device
152	luminescent layer of reverse oriented organic EL device
153	luminescent layer of organic EL device
154	luminescent layer of organic EL device
155	luminescent layer of organic EL device

161	high-potential-side electrode of forward oriented organic EL device	
162	high-potential-side electrode of reverse oriented organic EL device	
163	high-potential-side electrode of organic EL device	5
164	high-potential-side electrode of organic EL device	
165	high-potential-side electrode of organic EL device	10
171	low-potential-side electrode of forward oriented organic EL device	
172	low-potential-side electrode of reverse oriented organic EL device	
173	low-potential-side electrode of organic EL device	15
174	low-potential-side electrode of organic EL device	
175	low-potential-side electrode of organic EL device	20
181	resist	
201	odd-number frame	
202	even-number frame	
211	scanning potential	
212	signal potential	25
213	holding potential	
214	first feed potential	
215	pixel potential	
216	second feed potential	
231	current flowing through forward oriented organic EL device	30
232	current flowing through reverse oriented organic EL device	
233	current flowing through organic EL device	
234	current flowing through organic EL device	35
235	current flowing through organic EL device	

#### Best Mode for Carrying Out the Invention

[0036] Several preferred embodiments of this invention will be described with reference to the drawings hereinafter. First Embodiment

[0037] Fig. 1 is an equivalent circuit diagram of one pixel of an organic EL display device having a thin-film transistor according to a first embodiment of this invention, Fig. 2 is an equivalent circuit diagram showing the matrix construction of an organic EL display device equipped with a thin-film transistor according to the first embodiment of this invention, and Fig. 3 is a driving voltage diagram of an organic EL display device having a thin-film transistor according to the first embodiment of this invention.

[0038] The operation of the organic EL display device having the thin-film transistor of this embodiment will be described with reference to Figs. 1, 2, and 3.

[0039] As shown in Figs. 1 and 2, a data line 112 is formed so as to extend perpendicular to the direction of a scanning line 111. The scanning line 111 is connected

to a gate electrode of a first switching element (hereinafter referred to as a "switching thin-film transistor"), and one of a source or a drain of the switching thin-film transistor 121 is connected to the data line 112. The other of the source or the drain of the switching thin-film transistor 121 is connected to an electrode 113 of a storage capacitor 123, while another electrode of the storage capacitor 123 is connected to a first feeder 114.

[0040] A gate electrode of a second switching element (hereinafter referred to as a "current thin-film transistor") is electrically connected to the storage capacitor 123, and one of the source or the drain regions of the current thin-film transistor 122 is electrically connected to the first feeder. The other of the source or the drain regions of the current thin-film transistor 123 is electrically connected to an electrode (pixel electrode) 115 of an organic EL device 131 or 132. The first feeder is maintained at a fixed potential. Although in this embodiment the construction is such that the first feeder is connected to both the other electrode of the storage capacitor 123 and one of the source or the drain regions of the current thin-film transistor 122, the other electrode of the storage capacitor 123 and the one of the source or drain regions of the current thin-film transistor 122 may also be connected to separate wirings having fixed potentials instead of a common first feeder.

[0041] When the switching thin-film transistor 121 is selected by a scanning signal supplied to the scanning line 111, and the organic EL display device constructed in the manner described above is thereby turned ON, an image signal from the data line 112 is written to the storage capacitor 123 through the switching thin-film transistor 121. In a pixel in a displaying condition, a current flows from the first feeder 114 through the current thin-film transistor 122 and the pixel electrode 115 to a second feeder 116, or a current flows in the reverse direction, and the organic EL device 131 or the organic EL device 132, arranged in parallel, emits light. In other words, in this embodiment, in which the organic EL devices 131 and 132 are arranged in parallel, and the two organic EL devices are comprised of the organic EL device 131 (hereinafter referred to as a "forward oriented organic EL device") which emits light by a current flowing from the pixel electrode 115 to the second feeder 116 and the organic EL device 132 (hereinafter referred to as a "reverse oriented organic EL device") which emits light by a current flowing from the second feeder 116 to the pixel electrode 115. In a pixel in a non-displaying condition, no current flows, and the organic EL devices do not emit light.

[0042] Here, as one example of a system in which the sign (+ or -) of the first feeder with respect to that of the second feeder is inverted at predetermined intervals, a system in which inversion is effected for each vertical scanning period, that is, a frame inversion system, will be described with reference to Fig. 3.

[0043] Since the potential 214 of the first feeder 114 is higher than the potential 216 of the second feeder 116

in an odd-number frame 201, a current flows from the first feeder 114, through the current thin-film transistor 122, the pixel electrode 115, and the forward oriented organic EL device 131 to the second feeder 116. Since the first feed potential 214 is lower than the second feed potential 216 in an even-number frame 202, a current flows from the second feeder 116 through the reverse oriented organic EL device 132, the pixel electrode 115, and the current thin-film transistor 122 to the first feeder 114.

[0044] Although the signal potentials 212 of an odd-number frame 201 and an even-number frame 202 are equal in this case, they may also be different from each other. In Fig. 3, only the signal potential 212 before and after the building up of the potential of a gate electrode 211 is shown and the other potentials are omitted. The first feed potential 214 of the odd-number frame 201 is equal to the second feed potential 216 of the even-number frame 202, and the second feed potential 216 of the odd-number frame 201 is equal to the first feed potential 214 of the even-number frame 202 in this case. However, the potentials may be different from each other, as long as the voltage sign of the first feed potential 214 is inverted with respect to that of the second feed potential 216.

[0045] In this embodiment, an AC voltage is applied between the source terminal and the drain terminal of the switching thin-film transistor 121, and between the source terminal and the drain terminal of the current thin-film transistor 122, to cause an alternating current to flow, and a direct current flows between the first terminal and the second terminal of the forward oriented organic EL device 131, and between the first terminal and the second terminal of the reverse oriented organic EL device 132. This arrangement makes it possible to achieve a reduction in deterioration over time of the current thin-film transistor 122 due to a DC voltage or a direct current.

[0046] In this embodiment, the organic EL device consists of the forward oriented organic EL device 131 and the reverse oriented organic EL device 132, and the forward oriented organic EL device 131 is arranged in such a manner as to emit light by a current flowing from the pixel electrode 115 to the second feeder 116; the reverse oriented organic EL device 132 is arranged in such a manner as to emit light by a current flowing from the second feeder 116 to the pixel electrode 115. Further, the voltage sign of the first feed potential 214 with respect to the second feed potential 216 is inverted at predetermined intervals. This arrangement makes it possible to cause a direct current to flow between the first terminal and the second terminal of the forward oriented organic EL device 131 and between the first terminal and the second terminal of the reverse oriented organic EL device 132. At the same time, this arrangement makes it possible to cause an AC voltage to be applied, between the source terminal and the drain terminal of the current thin-film transistor 122 causing an

alternating current to flow. Thus a reduction in deterioration of the thin-film transistor 122 over time due to a DC voltage or a direct current can be realized. Further, either the forward oriented organic EL device 131 or the reverse oriented organic EL device 132 emits light during each period of the odd-number frame 201 and the even-number frame 202, whereby the luminous efficiency can be improved and the power consumption can be reduced.

[0047] Fig. 4 is a sectional view of the organic EL display device having a thin-film transistor of the first embodiment of this invention. Fig. 5 is a plan view of the organic EL display device having the thin-film transistor of the first embodiment of this invention. Sections taken along the lines A-A' and B-B' of Fig. 4 correspond to the sections taken along the lines A-A' and B-B' of Fig. 5.

[0048] In the forward oriented organic EL device 131, a current flows from a high-potential-side electrode 161 of the forward oriented organic EL device through a luminescent layer 151 of forward oriented organic EL device to a low-potential-side electrode 171 of the forward oriented organic EL device. In the reverse oriented organic EL device 132, a current flows from a high-electric-potential-side electrode 162 of the reverse oriented organic EL device through a luminescent layer 152 of reverse oriented organic EL device to a low-potential-side electrode 172 of the reverse oriented organic EL device. (Second Embodiment)

[0049] Fig. 6 is an equivalent circuit diagram of one pixel of an organic EL display device having a thin-film transistor of a second embodiment of this invention, Fig. 7 is an equivalent circuit diagram showing the matrix construction of the organic EL display device equipped with the thin-film transistor according to the second embodiment of the invention, and Fig. 8 is a driving voltage diagram of the organic EL display device having the thin-film transistor of the second embodiment of this invention.

[0050] The operation of the organic EL display device having a thin-film transistor of this embodiment will be described with reference to Figs. 6, 7, and 8. Since the construction of this embodiment is similar to that of the first embodiment, only those points which differ from the first embodiment will be explained.

[0051] The switching thin-film transistor 121, the storage capacitor 123, and the current thin-film transistor 122 operate in the same way as in the first embodiment.

[0052] In a pixel in a displaying condition, a current flows from the first feeder 114 through the current thin-film transistor 122 and the pixel electrode 115 to the second feeder 116, and the organic EL device 133 emits light. In a pixel in a non-displaying condition, no current flows, and the organic EL device emits no light.

[0053] Since the first feed potential 214 is higher than the second feed potential 216 in an odd-number frame 201, a current flows from the first feeder 114 through the current thin-film transistor 122, the pixel electrode 115, and the organic EL device 133 to the second feeder

116. Since the first feed potential 214 is lower than the second feed potential 216 in an even-number frame 202, a current flows from the second feeder 116 through a rectifier 141, the pixel electrode 115, and the current thin-film transistor 122 to the first feeder 114.

[0054] Although the organic EL device 133 is arranged in such a manner as to emit light by a current from the pixel electrode 115 to the second feeder 116, and the rectifier 141 is arranged in such a manner as to cause a current to flow from the second feeder 116 to the pixel electrode 115 in this example, the organic EL device 133 may also be arranged in such a manner as to emit light by a current from the second feeder 116 to the pixel electrode 115, and the rectifier 141 may be arranged in such a manner as to cause a current to flow from the pixel electrode 115 to the second feeder 116.

[0055] In this embodiment, an AC voltage is applied between the source terminal and the drain terminal of the switching thin-film transistor 121, and between the source terminal and the drain terminal of the current thin-film transistor 122, to cause an alternating current to flow, and a direct current flows between the first terminal and the second terminal of the organic EL device 133. This arrangement makes it possible to achieve a reduction in deterioration of the current thin-film transistor 122 over time due to a DC voltage or a direct current.

[0056] Further in this embodiment, the rectifier 141 is formed, the organic EL device 133 is arranged in such a manner as to emit light by a current flowing from the pixel electrode 115 to the second feeder 116 and the rectifier 141 is arranged in such a manner as to cause a current to flow from the second feeder 116 to the pixel electrode 115. Further the voltage sign of the first feed potential 214 with respect to the second feed potential 216 is inverted at predetermined intervals. This arrangement makes it possible to cause a direct current to flow between the first terminal and the second terminal of the organic EL device 133. At the same time, this arrangement makes it possible to cause an AC voltage to be applied between the source terminal and the drain terminal of the current thin-film transistor 122 causing an alternating current to flow. Thus a reduction in deterioration of the thin-film transistor 122 over time due to a DC voltage or a direct current can be realized.

[0057] Fig. 9 is a sectional view of the organic EL display device having a thin-film transistor of the second embodiment. Fig. 10 is a plan view of the organic EL display device having the thin-film transistor of the second embodiment. The sections taken along the lines A-A' and B-B' of Fig. 9 correspond to the sections taken along the lines A-A' and B-B' of Fig. 10.

[0058] In this embodiment, the rectifier 141 comprises a thin-film transistor for rectification connected to a gate terminal, and a source terminal or a drain terminal. The thin-film transistor for rectification is formed simultaneously with the switching thin-film transistor 121 and the current thin-film transistor 122. This arrangement makes it possible to realize a reduction in deterioration

of the current thin-film transistor 122 over time due to a DC voltage or a direct current without involving an additional producing process.

#### (Third Embodiment)

[0059] Fig. 11 is an equivalent circuit diagram of one pixel of an organic EL display device having a thin-film transistor of a third embodiment of this invention, Fig. 12 is an equivalent circuit diagram showing the matrix construction of the organic EL display device having a thin-film transistor of the third embodiment of the invention, and Fig. 13 is a driving voltage diagram of the organic EL display device having a thin-film transistor of the second embodiment of this invention.

[0060] The operation of the organic EL display device having a thin-film transistor of this embodiment will be described with reference to Figs. 11, 12, and 13. Since the construction of this embodiment is also similar to that of the first embodiment, only those points which differ from the first embodiment will be explained.

[0061] The switching thin-film transistor 121, the storage capacitor 123, and the current thin-film transistor 122 operate in the same way as in the first embodiment.

[0062] In a pixel in a displaying condition, a current flows from the first feeder 114 through the current thin-film transistor 122 and the pixel electrode 115 to a second feeder 116, and an organic EL device 134 emits light. In a pixel in a non-displaying condition, no current flows, and the organic EL device emits no light.

[0063] Since the first feed potential 214 is higher than the second feed potential 216 in an odd-number frame 201, a current flows from the first feeder 114 through the current thin-film transistor 122, the pixel electrode 115, a first rectifier 142, the organic EL device 134 and a fourth rectifier 145 to the second feeder 116. Since the first feed potential 214 is lower than the second feed potential 216 in an even-number frame 202, a current flows from the second feeder 116 through a third rectifier 144, the organic EL device 134, a second rectifier 143, the pixel electrode 115, and the current thin-film transistor 122 to the first feeder 114.

[0064] In other words, the first rectifier 142, the second rectifier 143, the third rectifier 144, and the fourth rectifier 145 form a full-wave rectification circuit. A current flows from a first electrode 117 to a second electrode 118 in the organic EL device 134, regardless of the levels of the first feed potential 214 and the second feed potential 216.

[0065] In this embodiment, an AC voltage is applied between the source terminal and the drain terminal of the switching thin-film transistor 121, and between the source terminal and the drain terminal of the current thin-film transistor 122, to cause an alternating current to flow, and a direct current flows between the first electrode 117 and the second electrode 118 of the organic EL device 134. This arrangement makes it possible to achieve a reduction in deterioration of the current thin-



film transistor 122 over time due to a DC voltage or a direct current.

[0066] Further, in this embodiment, the first electrode 117 and the second electrode 118 are formed, and further, the first rectifier 142, the second rectifier 143, the third rectifier 144, and the fourth rectifier 144 are formed; and the organic EL device 134 is arranged in such a manner as to emit light by a current flowing from the first electrode 117 to the second electrode 118. The first rectifier 142, the second rectifier 143, the third rectifier 144, and the fourth rectifier 145 are arranged in such a manner as to permit current to flow from the pixel electrode 115 to the first electrode 117, from the second electrode 118 to the pixel electrode 115, from the second feeder 116 to the first electrode 117, and from the second electrode 118 to the second feeder 116, respectively. Further, as disclosed in claim 7, the voltage sign of the first feeder 114 with respect to the second feeder 116 is inverted at predetermined intervals. This arrangement makes it possible to cause a DC voltage to be applied between the first terminal and the second terminal of the organic EL device 134 causing a direct current to flow. Further, this causes an AC voltage to be applied, between the source terminal and the drain terminal of the current thin-film transistor 122 causing an alternating current to flow. Thus a reduction in deterioration of the current thin-film transistor 122 over time due to a DC voltage or a direct current can be realized. At the same time, since the organic EL device 134 emits light during both periods of the odd-number frame 201 and the even-number frame 202, the luminous efficiency can be improved and the power consumption can be reduced.

[0067] Fig. 14 is a sectional view of the organic EL display device having a thin-film transistor of the third embodiment. Fig. 15 is a plan view of the organic EL display device having the thin-film transistor of the third embodiment. The sections taken along the lines A-A' and B-B' of Fig. 14 correspond to sections taken along the lines A-A' and B-B' of Fig. 15.

[0068] In this embodiment, the first rectifier 142, the second rectifier 143, the third rectifier 144, and the fourth rectifier 145 are formed by a PN junction or a PIN junction, and are formed simultaneously with the switching thin-film transistor 121, or the current thin-film transistor 122. Due to this arrangement, a reduction in deterioration of the current thin-film transistor 122 due to a DC voltage or a direct current can be achieved, and further, an improvement in luminous efficiency and a reduction in power consumption can be achieved by causing the organic EL device 134 to emit light during the periods of both the odd-number frame 201 and the even-number frame 202 without involving an additional producing process.

[0069] Although in this embodiment described above, two transistors, i.e. a switching thin-film transistor and a current thin-film transistor are provided in each pixel, it is to be understood that a construction in which each

pixel has one transistor provides the same effect. Further, although in the above embodiment a frame inversion system is employed, the same effect will be obtained by employing it together with a voltage sign inverting system of the first feeder with respect to the second feeder for each scanning line, each data line, or each pixel.

[0070] As described above, a construction employing a thin-film transistor as a switching element is adopted in this embodiment. The deterioration of a thin-film transistor over time due to a direct current or a DC voltage is considerable. However, a significant reduction in deterioration over time can be realized by using the construction of this invention. The construction in accordance with this invention can improve the luminous efficiency of the luminescent element other than an organic EL device that can emit light when a current flows in only one direction by rectification.

#### Industrial Applicability

[0071] The display apparatus in accordance with this invention can be used as a display device comprising a current driving type luminescent element such as an organic EL device or an inorganic EL device, and a switching element for driving the luminescent element such as TFT.

#### Claims

1. A current driving type emissive display apparatus comprising:

a plurality of scanning lines and a plurality of data lines; and  
a respective combination of at least one thin-film transistor and a luminescent element corresponding to each intersection of said scanning lines and said data lines,  
wherein an AC voltage is applied between the source and drain terminals of said at least one thin-film transistor, and  
a DC voltage is applied between first and second terminals of said luminescent element.

2. A current driving type emissive display apparatus comprising:

a plurality of scanning lines and a plurality of data lines; and  
a respective combination of at least one thin-film transistor and a luminescent element corresponding to each intersection of said scanning lines and said data lines,  
wherein an alternating current flows between the source and drain terminals of said at least one thin-film transistor and  
wherein a direct current flows between first and

second terminals of said luminescent element.

3. A current driving type emissive display apparatus comprising:

a plurality of scanning lines;  
a plurality of data lines;  
a first feeder; and  
a second feeder,  
said current driving type emissive display apparatus further having, in correspondence with each intersection of said scanning lines and said data lines:

a first switching element;  
a second switching element;  
a storage capacitor;  
a pixel electrode and  
a luminescent element,  
said first switching element controlling conduction between a data line and said storage capacitor by means of a potential of a scanning line, and said second switching element controlling conduction between said first feeder and said pixel electrode by means of a potential of said storage capacitor, to thereby control a current flowing through said luminescent element arranged between said pixel electrode and said second feeder,  
wherein said luminescent element comprises a first luminescent element that emits light by a current flowing from said pixel electrode to said second feeder and a second luminescent element that emits light by a current flowing from said second feeder to said pixel electrode, the first and the second luminescent elements being arranged in parallel.

4. A current driving type emissive display apparatus comprising:

a plurality of scanning lines;  
a plurality of data lines;  
a first feeder; and  
a second feeder,  
said current driving type emissive display apparatus further having, in correspondence with each intersection of said scanning lines and said data lines:

a first switching element;  
a second switching element;  
a storage capacitor;  
a pixel electrode and  
a luminescent element,  
said first switching element controlling con-

duction between a data line and said storage capacitor by means of a potential of a scanning line, and said second switching element controlling conduction between said first feeder and said pixel electrode by means of a potential of said storage capacitor, to thereby control a current flowing through said luminescent element arranged between said pixel electrode and said second feeder,

wherein said luminescent element and a rectifier are arranged in parallel between said pixel electrode and said second feeder, said luminescent element emits light by a current flowing from said pixel electrode to said second feeder, and said rectifier is formed in a manner such that a current flows from said second feeder to said pixel electrode.

5. A current driving type emissive display apparatus comprising:

a plurality of scanning lines;  
a plurality of data lines;  
a first feeder; and  
a second feeder,  
said current driving type emissive display apparatus further having, in correspondence with each intersection of said scanning lines and said data lines:

a first switching element;  
a second switching element;  
a storage capacitor;  
a pixel electrode and  
a luminescent element,  
said first switching element controlling conduction between a data line and said storage capacitor by means of a potential of a scanning line, and said second switching element controlling conduction between said first feeder and said pixel electrode by means of a potential of said storage capacitor, to thereby control a current flowing through said luminescent element arranged between said pixel electrode and said second feeder,  
wherein said luminescent element and a rectifier are arranged in parallel between said pixel electrode and said second feeder, said luminescent element emits light by a current flowing from said second feeder to said pixel electrode, and said rectifier is formed in a manner such that a current flows from said pixel electrode to said second feeder.

6. A current driving type emissive display apparatus comprising:

a plurality of scanning lines;  
a plurality of data lines;  
a first feeder; and  
a second feeder,

5

said current driving type emissive display apparatus further having, in correspondence with each intersection of said scanning lines and said data lines:

10

a first switching element;  
a second switching element;  
a storage capacitor;  
a pixel electrode and  
a luminescent element, said first switching element controlling conduction between a data line and said storage capacitor by means of a potential of a scanning line, and said second switching element controlling conduction between said first feeder and said pixel electrode by means of a potential of said storage capacitor, to thereby emit light by a current following through said luminescent element, which is arranged between a first electrode connected to said pixel electrode and a second electrode connected to said second feeder, said current driving type emissive display apparatus further comprising:

15

20

25

30

a first rectifier constructed so as to cause a current to flow from said pixel electrode to said first electrode;

35

a second rectifier constructed so as to cause a current to flow from said second electrode to said pixel electrode;

a third rectifier constructed so as to cause a current to flow from said second feeder to said first electrode; and

40

a fourth rectifier constructed so as to cause a current from said second electrode to said second feeder,

wherein said luminescent element emits light by a current flowing from said first electrode to said second electrode.

45

7. A method for driving a current driving type emissive display apparatus as claimed in any one of claims 3, 4, and 5, wherein a voltage between said first feeder and said second feeder is inverted at predetermined intervals.

50

8. A method for producing a current driving type emissive display apparatus according to claim 4 or 5, wherein at least one of said first rectifier, said second rectifier, said third rectifier, and said fourth rec-

55

tifier comprises a switching element for rectification connected to a gate, a source, or a drain terminal, and said switching element for rectification is formed simultaneously with at least one of said first and said second switching elements.

9. A current driving type emissive display apparatus according to claim 4 or 5, wherein at least one of said first rectifier, said second rectifier, said third rectifier, and said fourth rectifier is formed by a PN junction or a PIN junction, and formed simultaneously with at least one of said first and said second switching elements.

FIG. 1

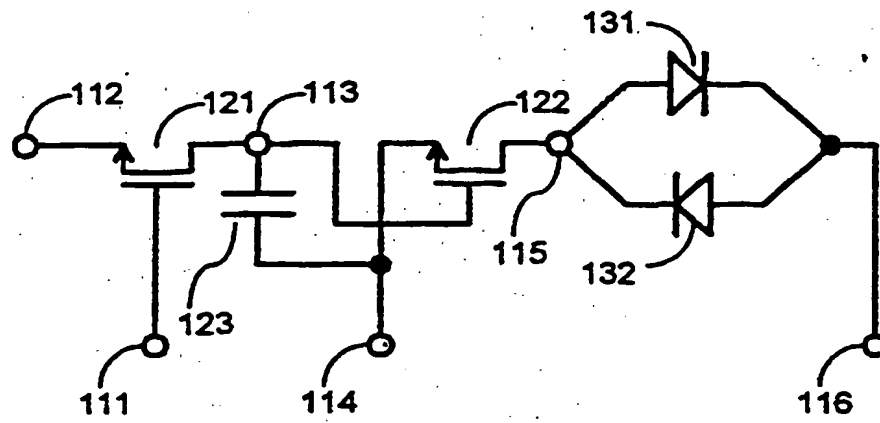


FIG. 2

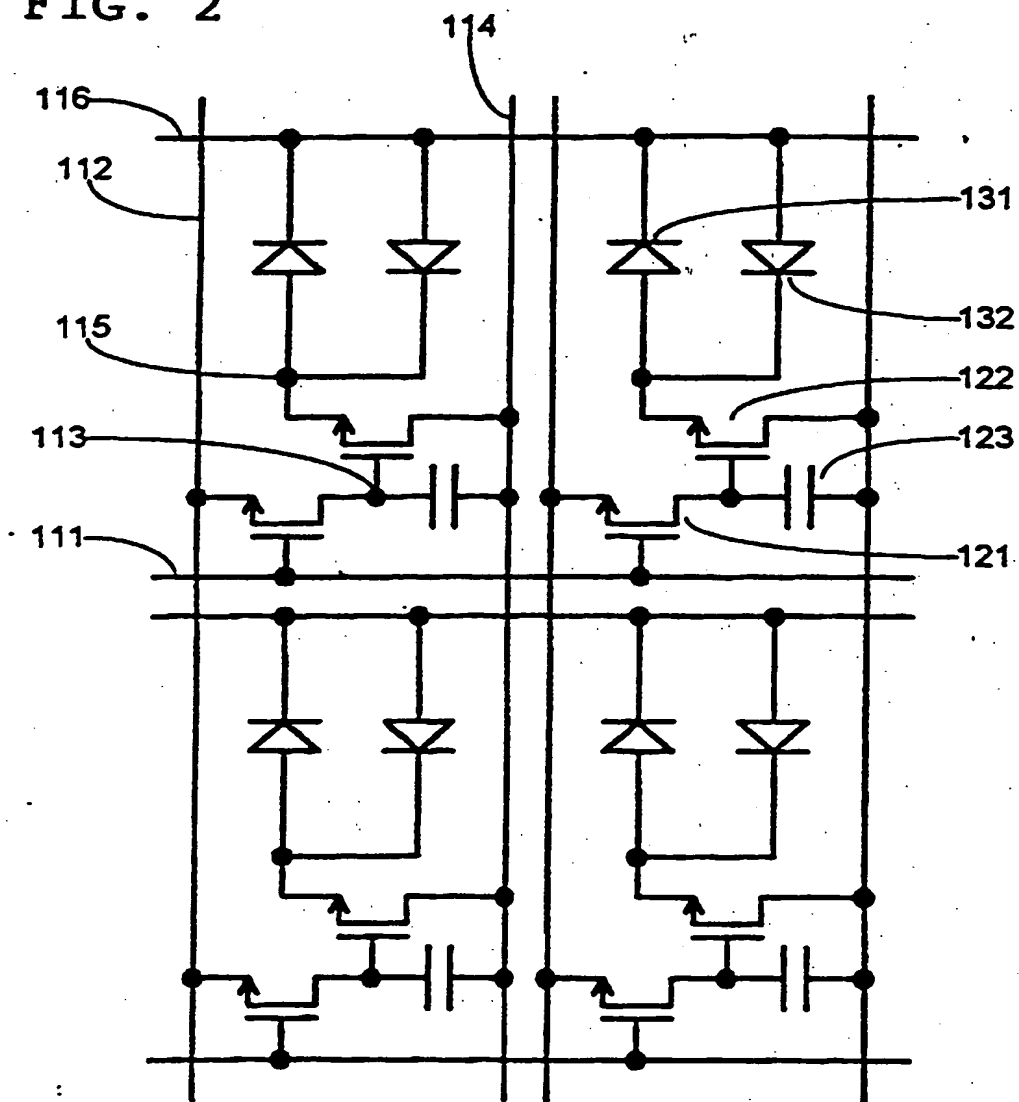


FIG. 3

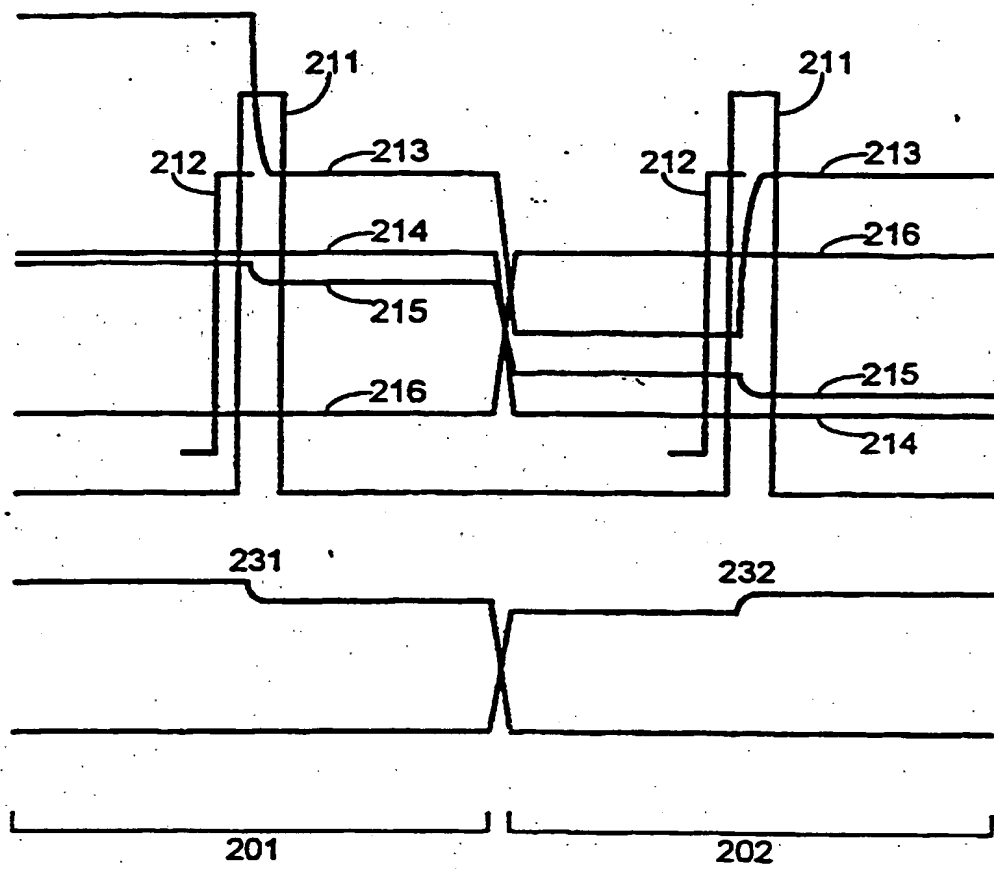


FIG. 4

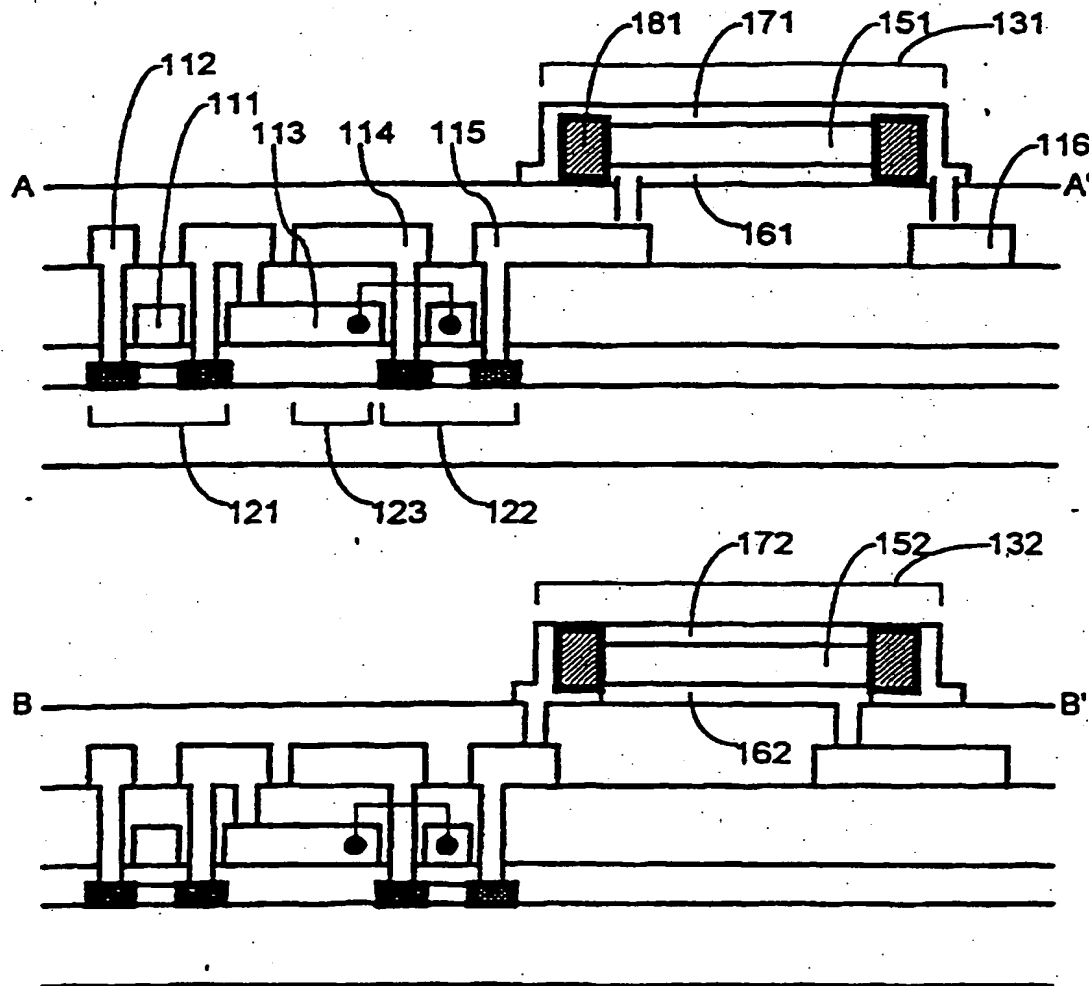


FIG. 5

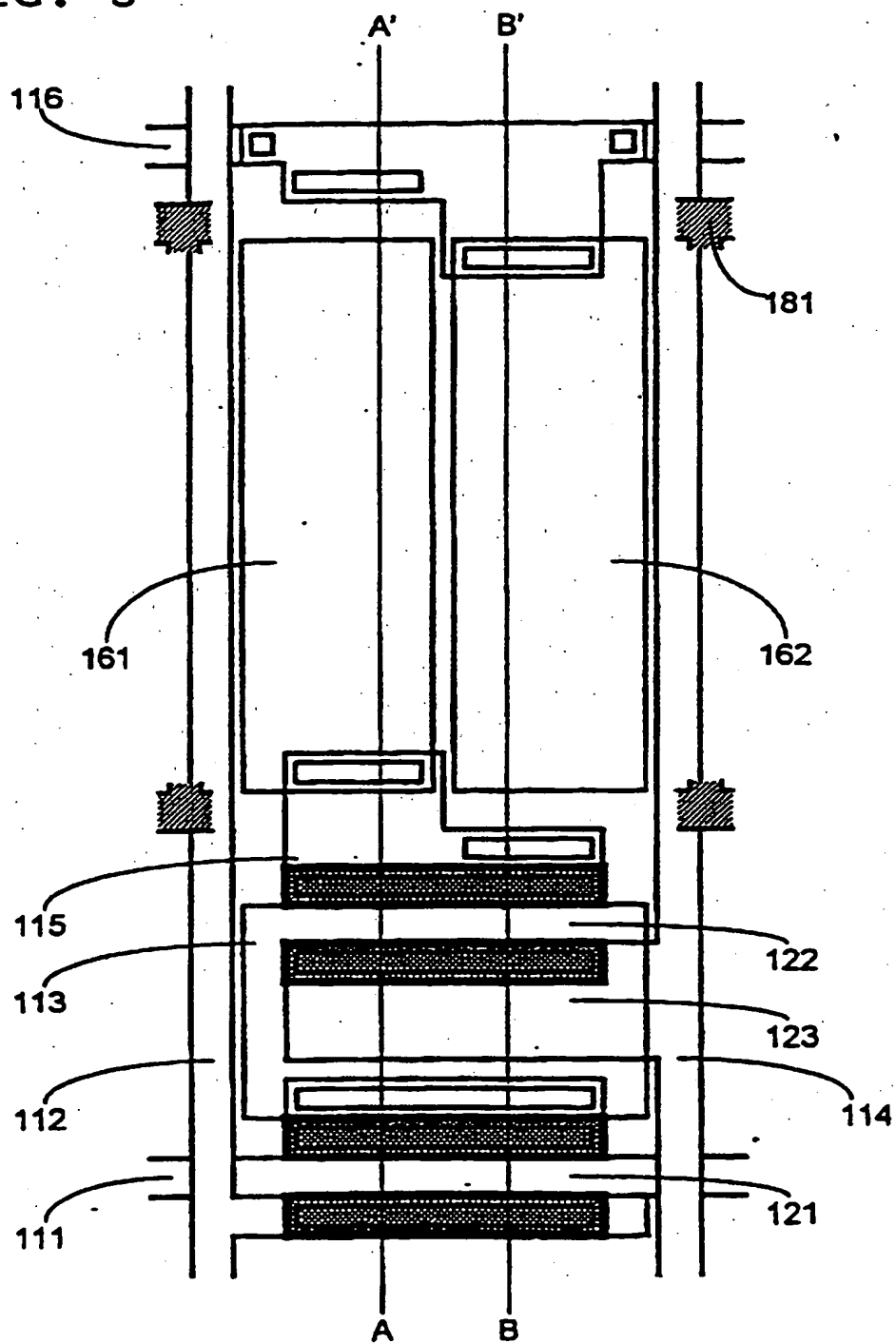




FIG. 6

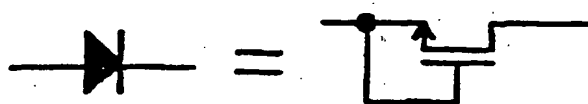
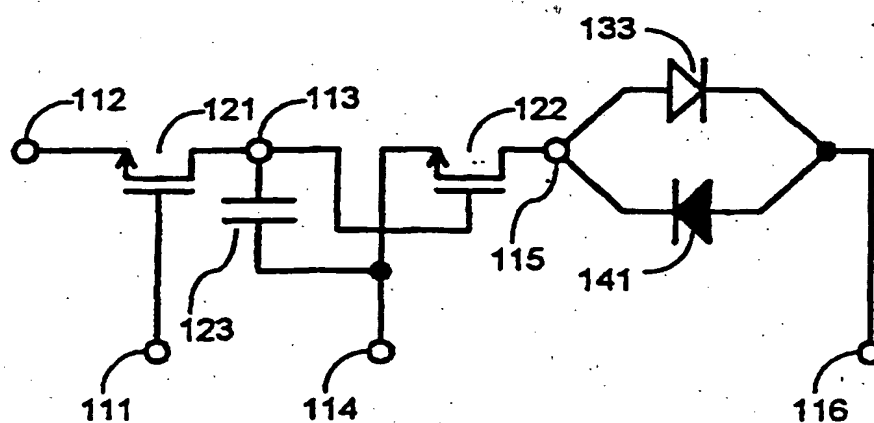


FIG. 7

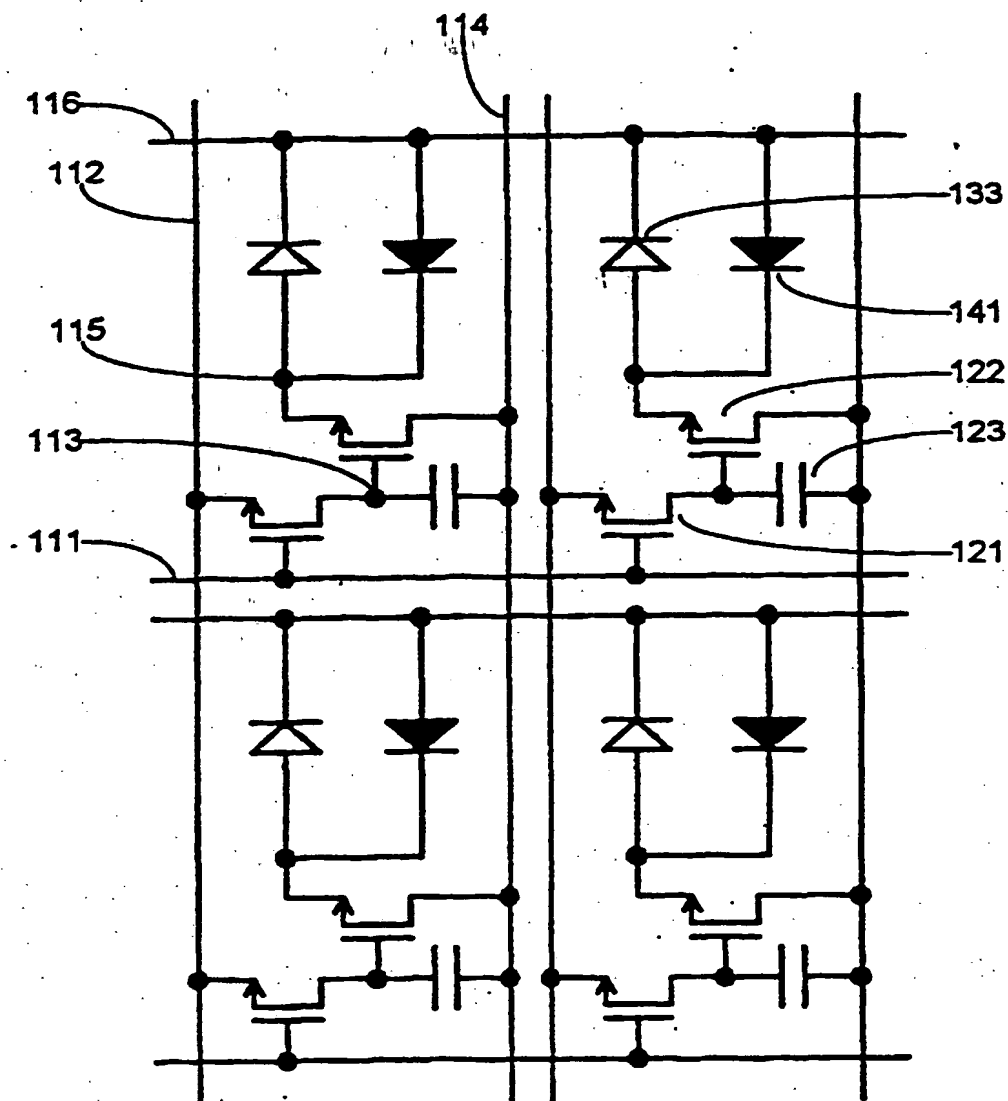
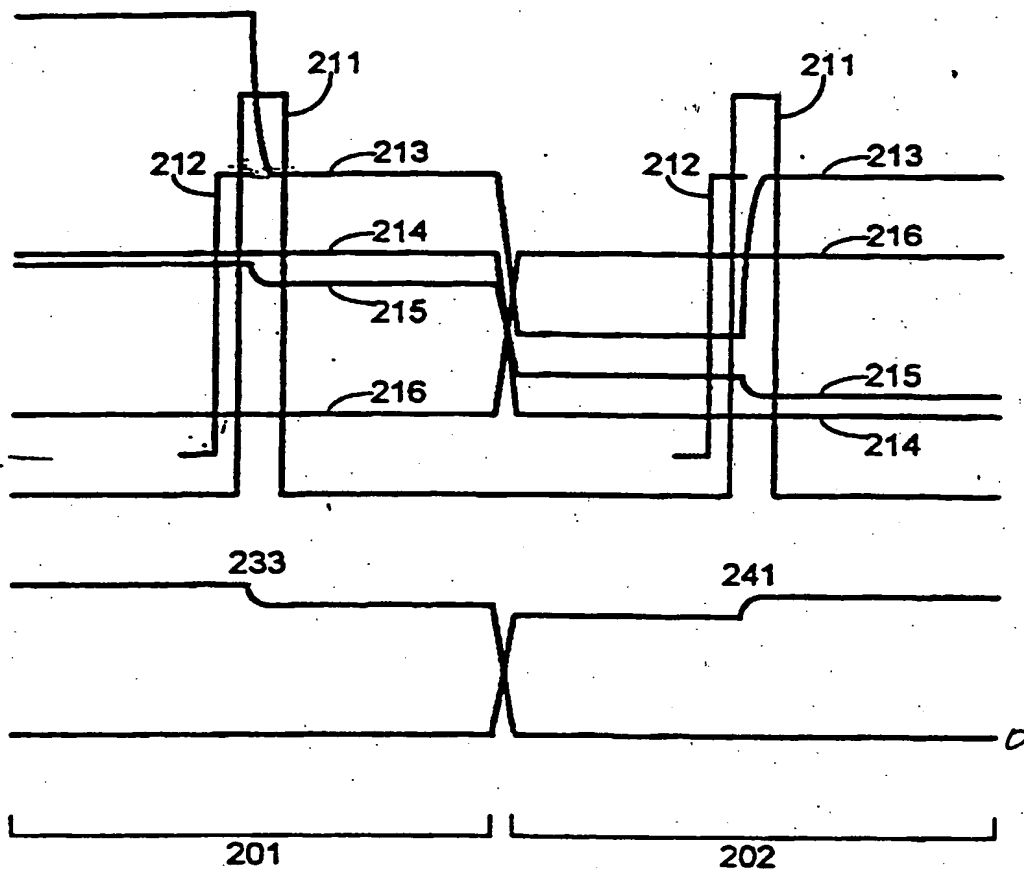


FIG. 8



BEST AVAILABLE COPY

FIG. 9

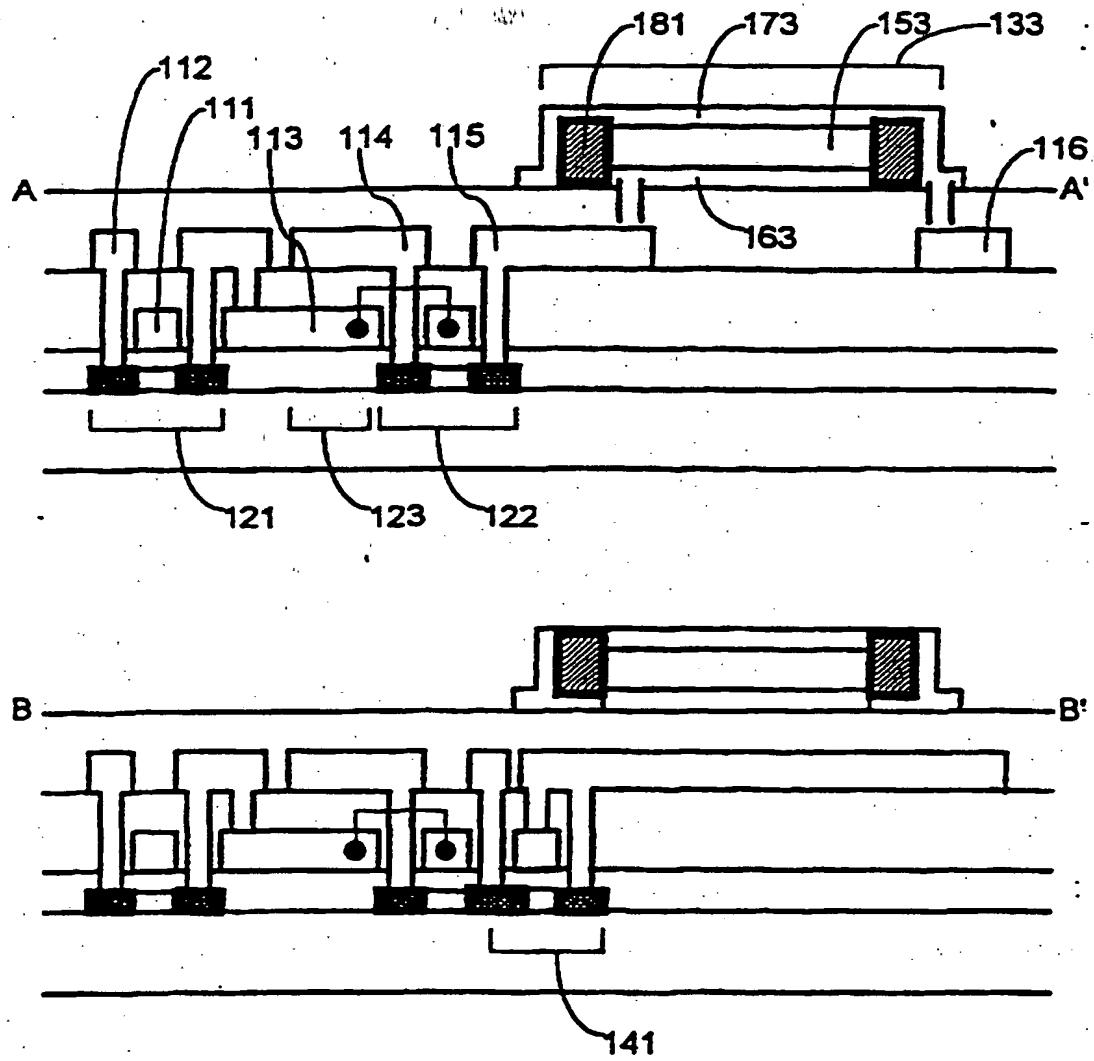


FIG. 10

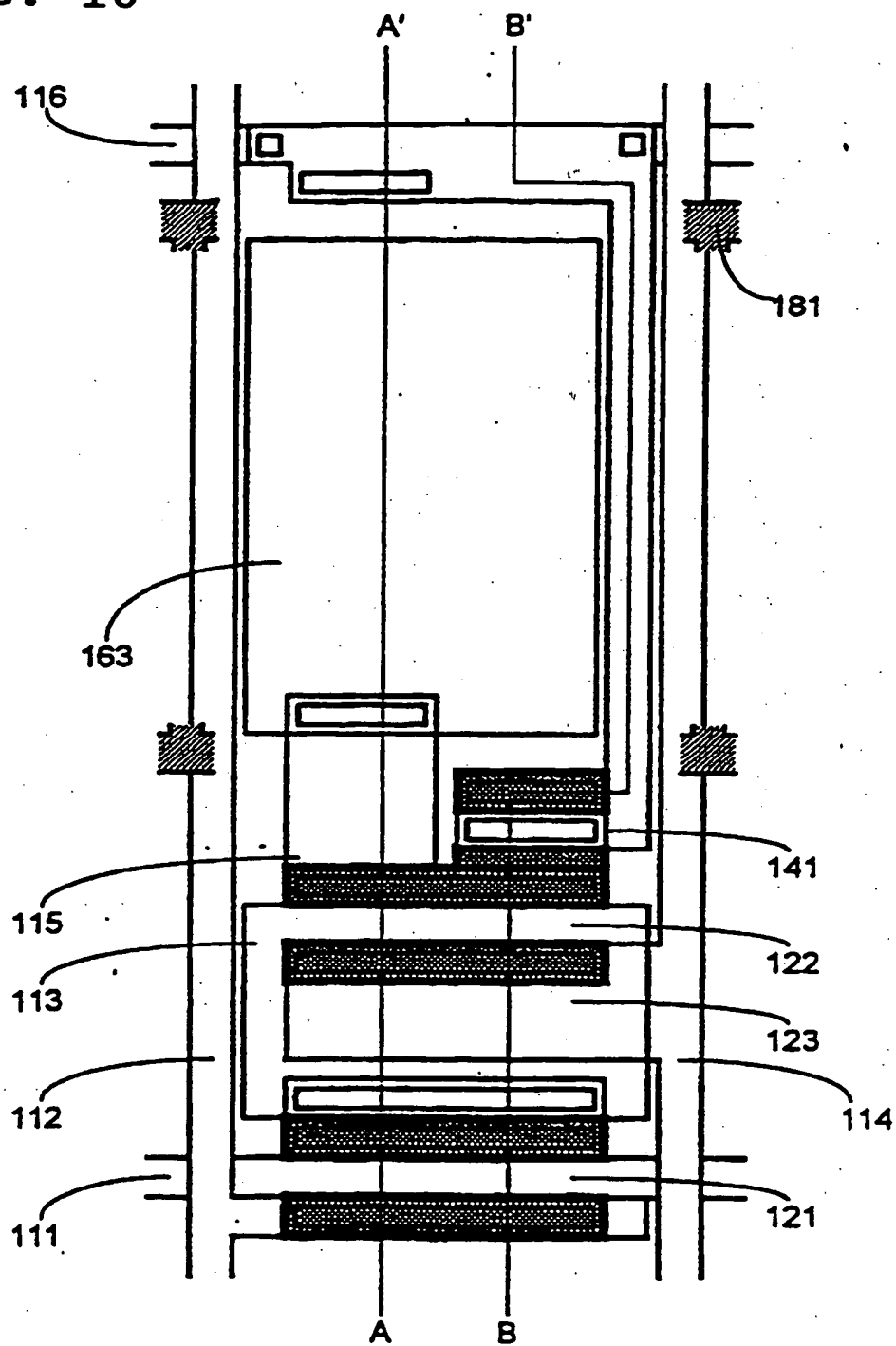


FIG. 11

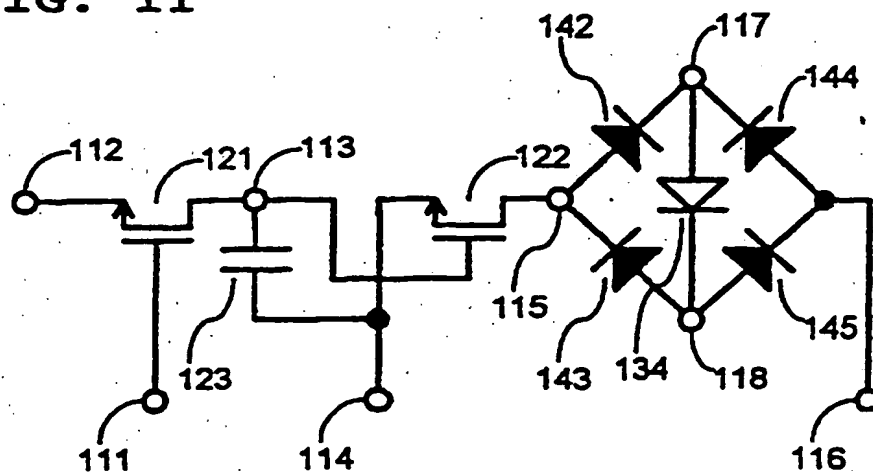


FIG. 12

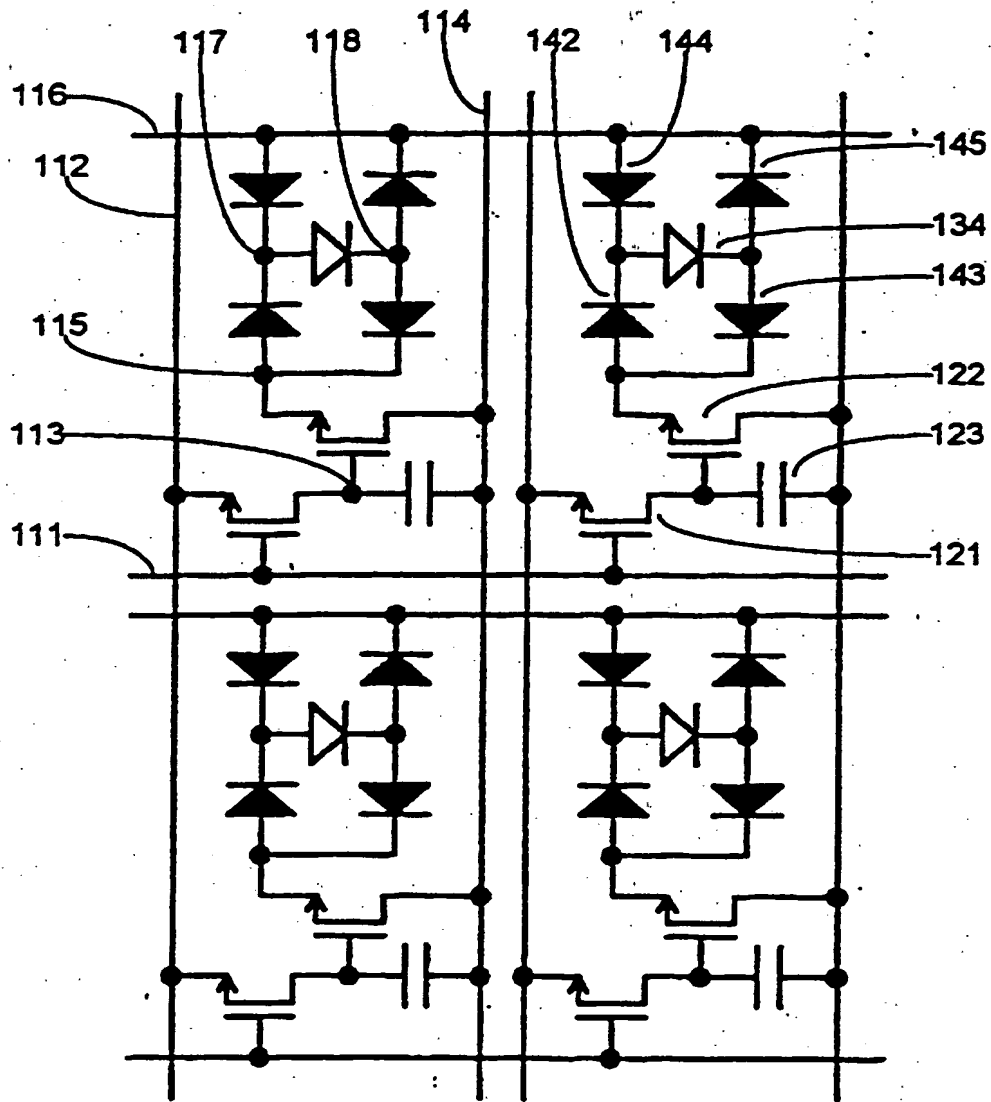
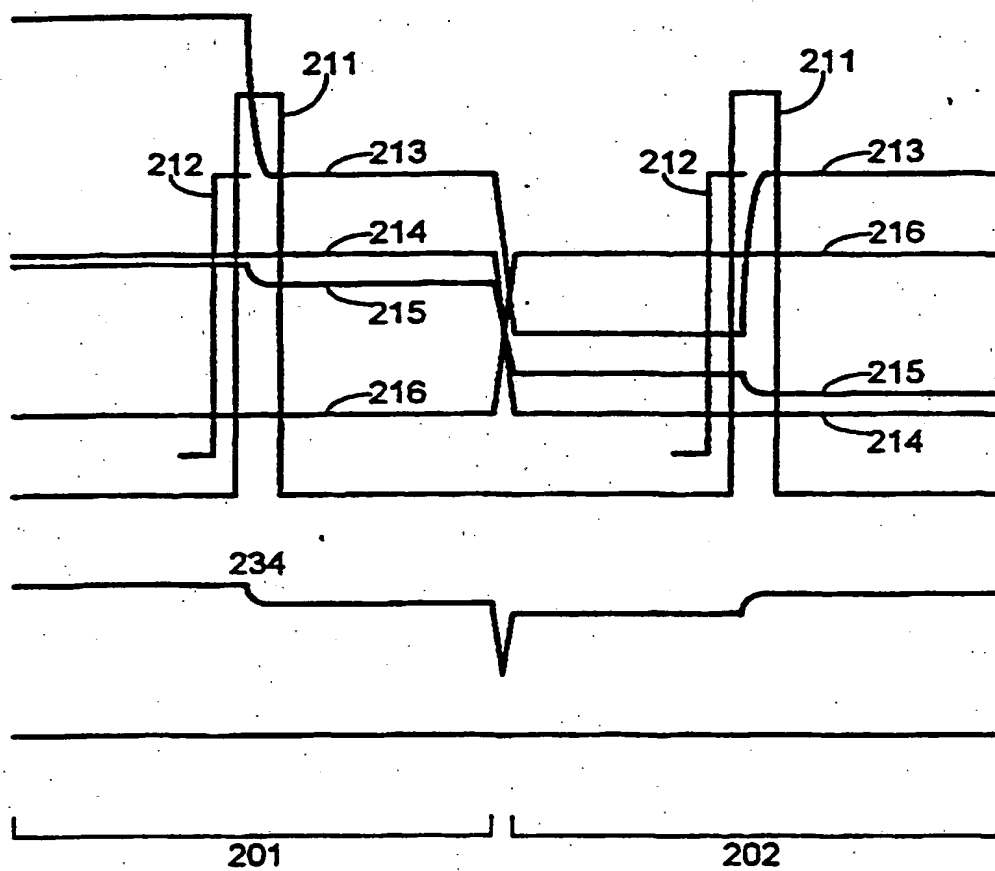


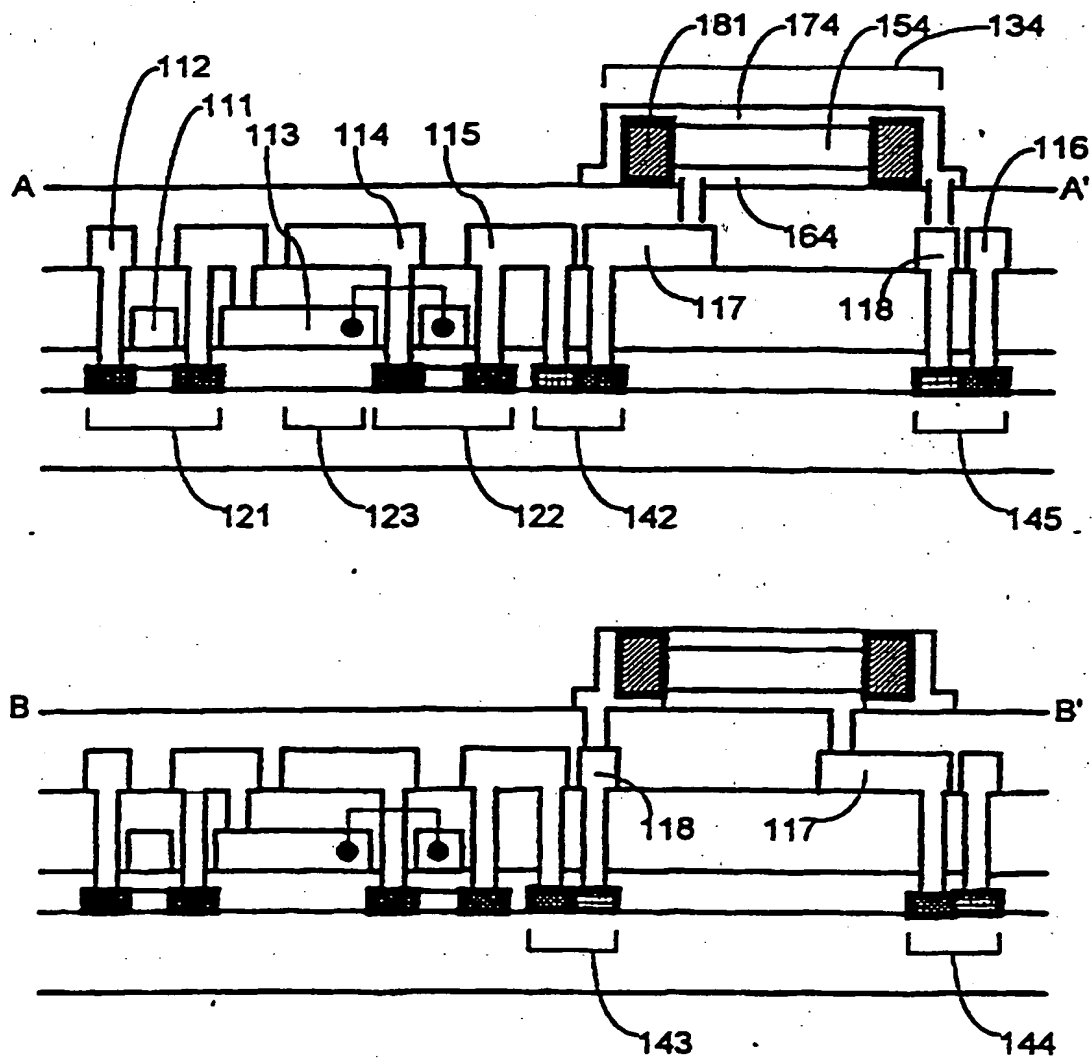
FIG. 13





BEST AVAILABLE COPY

FIG. 14



BEST AVAILABLE COPY

FIG. 15

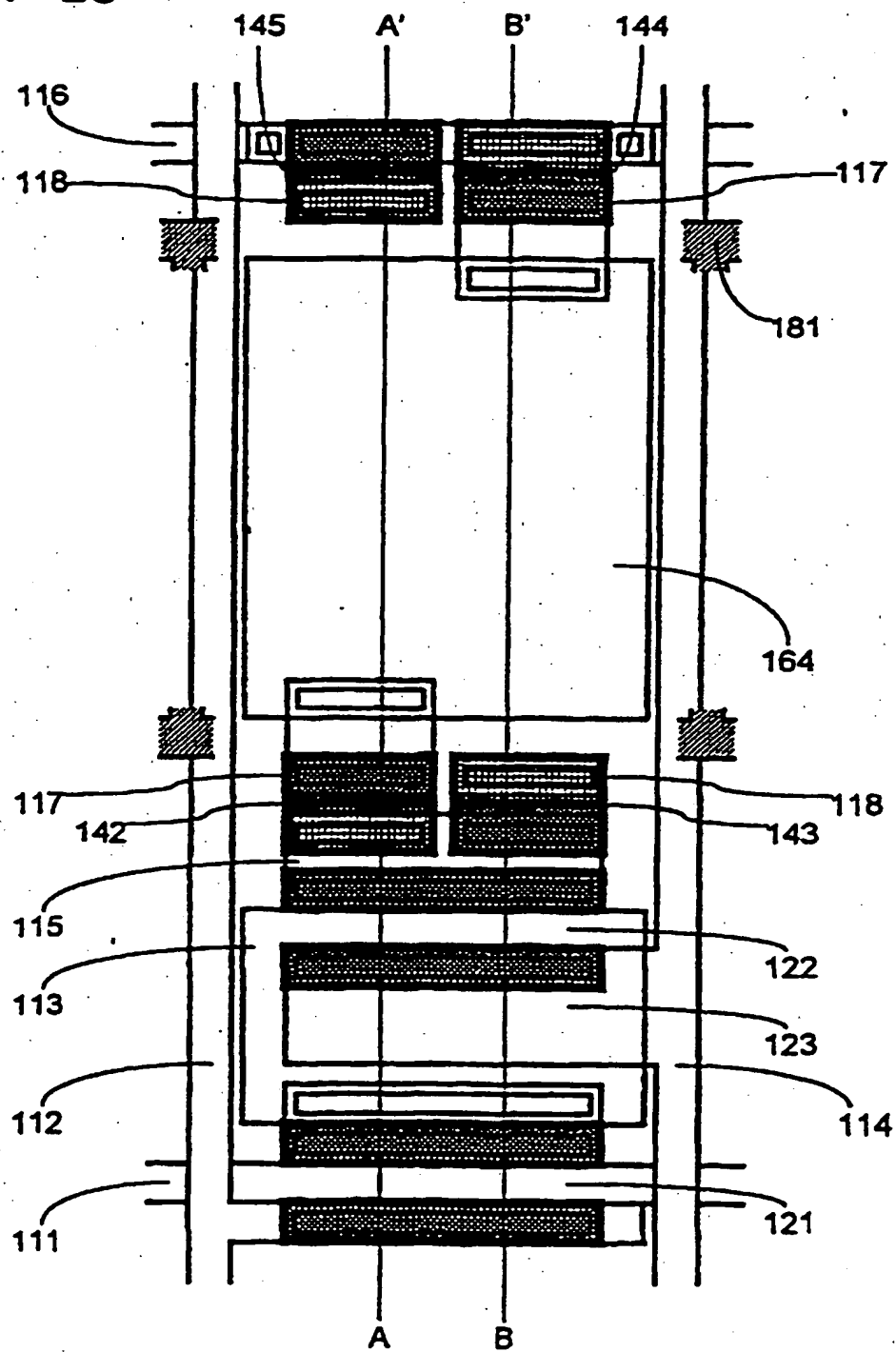


FIG. 16

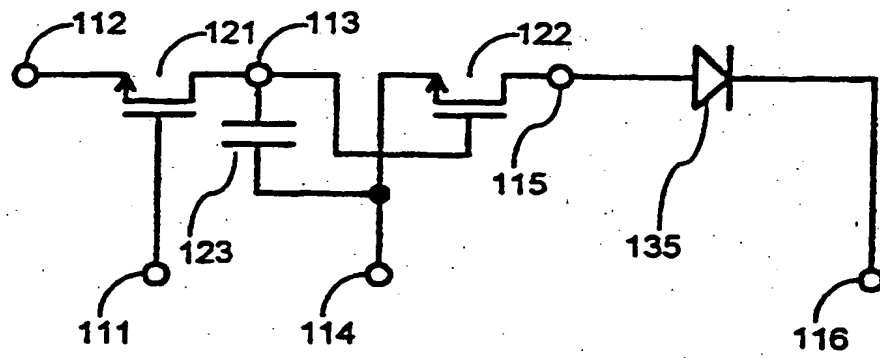


FIG. 17

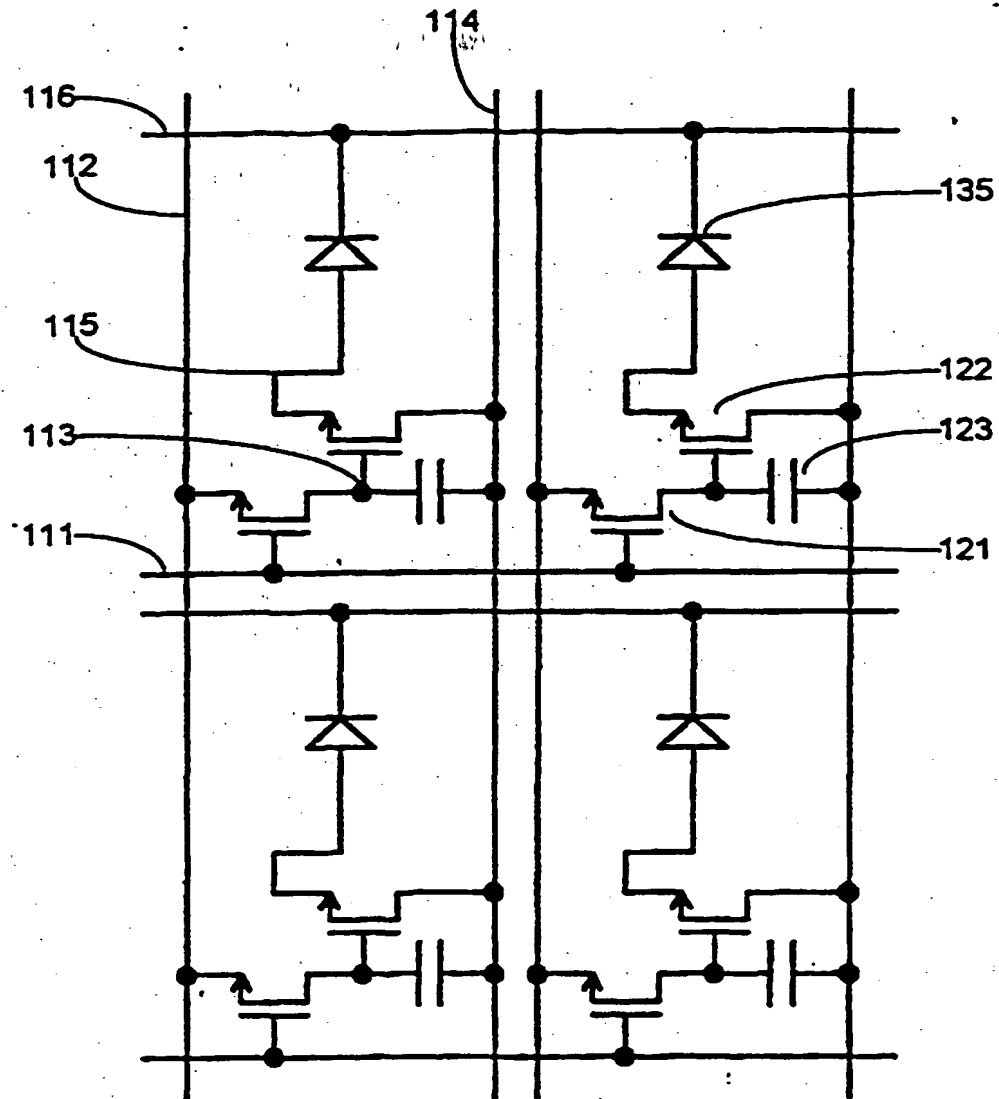


FIG. 18

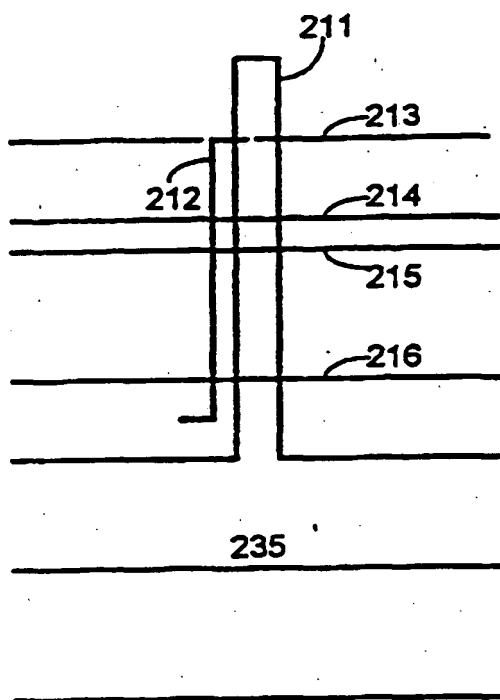


FIG. 19

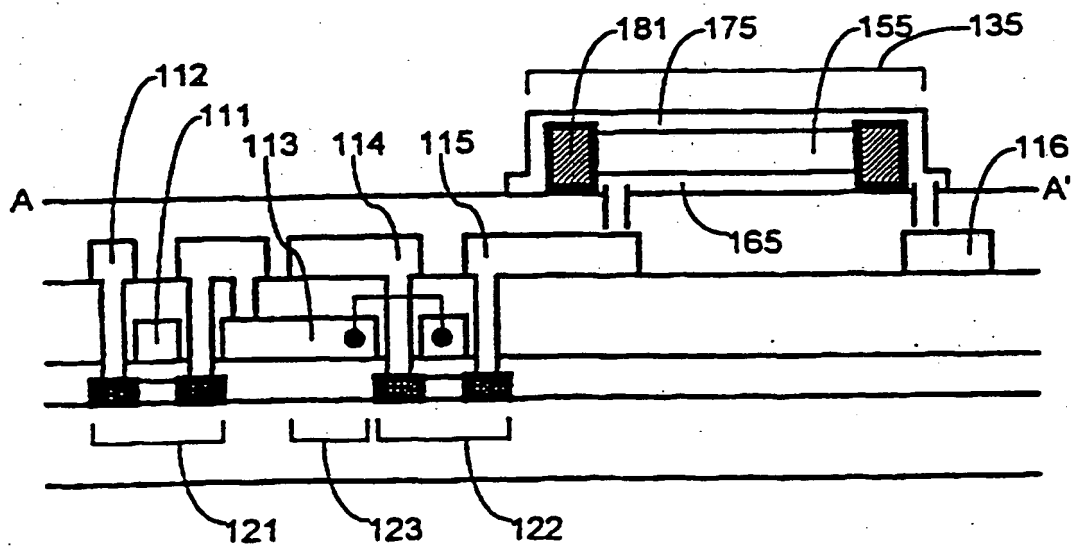
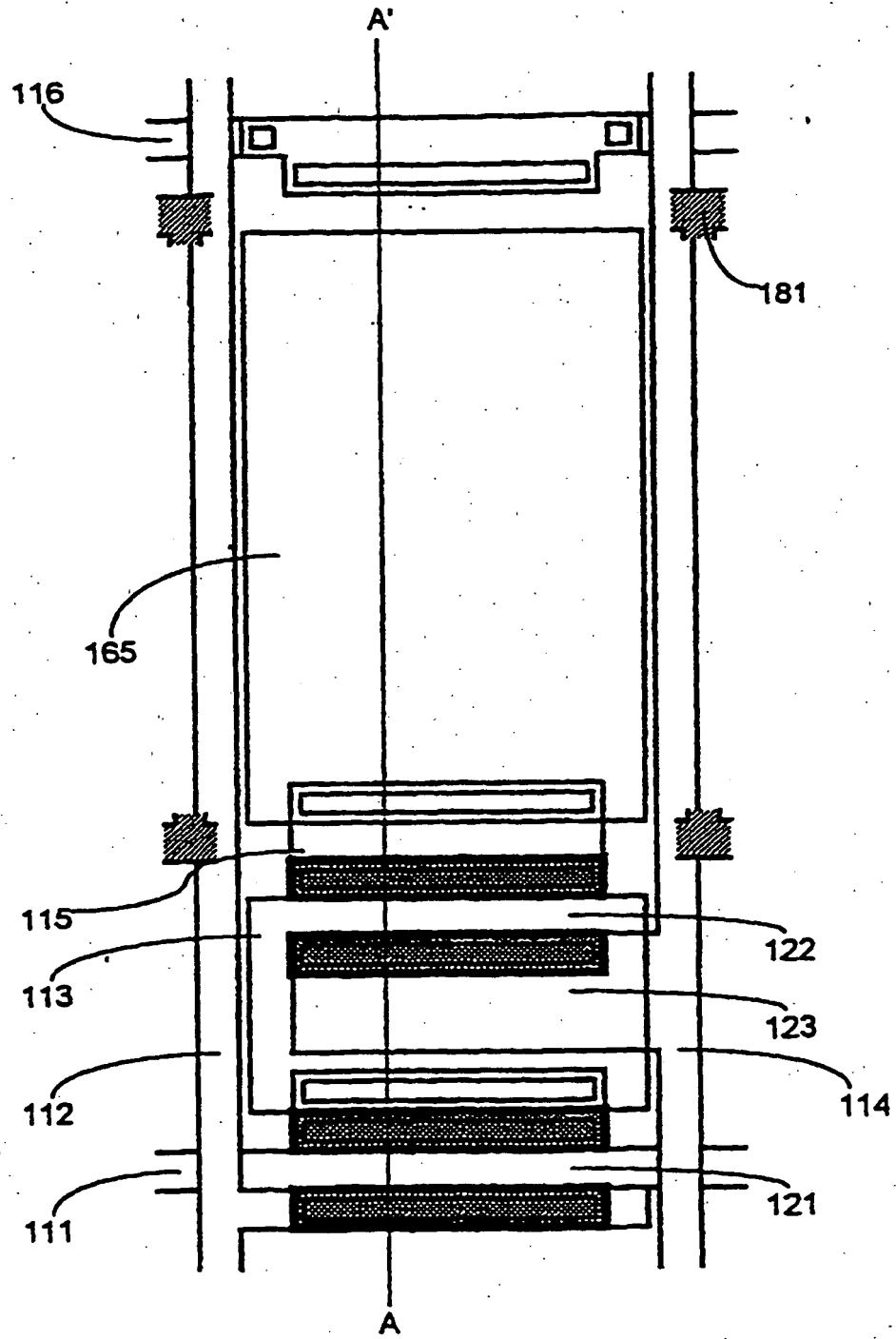


FIG. 20



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP98/00646

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> Int.Cl <sup>6</sup> G09G3/30, H05B33/08, H01L33/00 According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) Int.Cl <sup>6</sup> G09G3/20-38, H05B33/00-28, H01L33/00 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926-1998 Toroku Jitsuyo Shinan Koho 1994-1998 Kokai Jitsuyo Shinan Koho 1971-1995 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 6-230745, A (Fuji Xerox Co., Ltd.), August 19, 1994 (19. 08. 94)	1-3, 6-9
Y	JP, 60-183459, U (NEC Corp.), December 5, 1985 (05. 12. 85)	1-3, 6-9
Y	JP, 56-120795, U (K.K. Sakazume Seisakusho), September 14, 1981 (14. 09. 81)	6-9
Y	JP, 7-335941, A (Iwaki Electronics Co., Ltd.), December 22, 1995 (22. 12. 95)	1-3, 6-9
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search May 12, 1998 (12. 05. 98)		Date of mailing of the international search report May 26, 1998 (26. 05. 98)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)